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(Under Section 91, subsections (2) and (4) (a) of the Patents and Designs Acts, 1907 to 1932, a single Complete Specification was left in respect of these Applications and of Application No. 36014/35, and was laid open to inspection on June 30, 1936.)



COMPLETE SPECIFICATION

Improvements in Means for Damping Vibrations of Aircraft Fixed Wings, or Supporting Surfaces having a Limited Pivotal Movement

I, AUGUSTE LOUIS MARIE ANTOINE ROUX, of French nationality, of 42, rue de Dantzig, Paris (Seine), France, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to means for damping the vibrations of aircraft fixed wings or supporting surfaces having a limited pivotal movement.

It is already known to use reciprocable inertia means for damping vibrations of rotating wings.

The object of the present invention is the particular application of such means and to permit those means to respond better than hitherto to the various requirements of practice and in particular to be simpler and more effective.

The fixed wing or supporting surface of aircraft according to the present invention is characterised by the feature that it comprises at least one vibration damping system arranged in such a way as to destroy the kinetic energy tending to maintain the said vibrations, the assembly being such as to avoid the accumulation of the vibratory energy.

The invention in particular makes use of reciprocable inertia masses of which the intrinsic frequency is preferably as near as possible to that of the said parts, and which are capable of doing sufficient work to destroy the vibratory energy at each pulsation and thus prevent it from accumulating.

The invention is illustrated by way of example in the accompanying drawings, in which:—

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Figure 1 shows in partial diagrammatic elevation a beam of an aircraft wing fixed or built in at one end and provided with a device for damping the oscillations, this unit being constructed in accordance with the invention.

Figure 2 shows in section a damping device, designed in accordance with one form of construction of the invention:

Figures 3 and 4 show, in partial elevation and in partial plan respectively, a similar device designed according to another form of construction of the invention;

Figure 5 shows in elevation, with parts in section, a damping device according to the invention, this device being shown mounted upon an aeroplane wing;

Figure 6 shows the means for securing in position the damping device of Fig. 5.

Figures 7 and 8 show, in sectional elevation and in partial plan respectively, an aileron provided with a device according to the invention;

Figure 9 shows curves by means of which the location of the damping devices in question can be obtained.

The vibrations of the constituent parts of an aircraft wing are generally occasioned by repeated impulses, giving at each pulsation a very small quantity of energy; but these quantities are added to one another, and finish in favour of the resonance of the resilient system which each of the said parts constitutes, by representing a considerable sum of energy.

The energy accumulated in a vibratory movement becomes in a sense potential energy, subjecting the parts to very powerful forces.

The invention starts from this principle, that the cause of all vibratory movement is generally a very small quantity of energy, and it proposes, in order to obviate the accumulation of this vibratory energy, to provide means which are capable of absorbing at each pulsation the small quantity of energy brought into play and dissipating it in electrical, mechanical, or other form.

To this end, the said means may for example be essentially constituted, for each part to be damped, by at least one reciprocable inertia mass preferably arranged in proximity to a crest or antinode of oscillation, and such that its mass is capable of doing the desired amount of work, the intrinsic frequency of such a system being preferably as near as possible to that of the said part, though appreciable results can be obtained for rather different frequencies.

It should be understood that the characteristics of the said reciprocable inertia mass, may be chosen in any suitable way in order to obtain the desired frequency provided that these various characteristics enable this to be attained with as small a volume as possible.

The antagonistic force may be exerted by any resilient means, for instance by helical springs 1 (Figures 1 to 3), or other springs, acting on opposite sides of a mass 2, substantially constituting the reciprocable inertia means and being suitably guided, the said springs being either compression or tension springs.

In certain cases one might content oneself with a reciprocable system comprising exclusively the said mass and the said resilient means. But it will generally be necessary to combine therewith damping means so arranged as to act, either by mechanical friction or by forcing a liquid or a gas through throttled orifices or by magnetic action, electro-dynamic or like action, or in some other way. For example a core moving in the same way as the pistons 2 of Figures 2 and 3 may generate Foucault current or currents in a coil and eventually develop heat.

Such a system will generally possess, on account of its damping, a much greater margin of resonance than an undamped system, and will always be capable of constituting a damper of vibrations, owing to the lag with which the reciprocable inertia mass follows the displacements of its support, to which it is connected by the resilient means.

A device according to the invention will be constructed by proceeding for example according to one of the following modes of realisation:—

According to one of these embodiments

(Figures 3 and 4), the mass 2 for example, or members integral with or rigidly secured to the latter, are caused to rub upon suitable guides, in such a manner as to occasion damping by friction. To this end the said mass is for example carried by two jaws 3, capable of coming into frictional contact, through the medium, it may be, of suitable packings 4, with guides 5, integral with or rigidly secured to the part (a beam or wing, for example) of which it is desired to damp the oscillations.

The frictional surfaces will preferably be so arranged that the friction remains almost constant, for which reason the surfaces in question are made for example of guaiacum and steel respectively.

According to another mode of realisation (Figure 2), the mass 2 consists of a piston displaceable in a cylinder 7, carried by the part to be braked, and adapted, in moving, to pass liquid or a gas, that is to say air, through a pipe 8, upon which there is at least one throttling member, for instance a valve 9.

The liquid damping will be suitable when the frequency oscillations to be damped is comparatively low, whereas it would be advisable to utilise gaseous damping for the higher frequencies.

The damping may advantageously be provided in such a way as to increase when the piston 2 or the like approaches the ends of its stroke, for which reason for example the said piston closes at this moment the orifice through which the pipe 8 opens into the cylinder.

Furthermore, in order to obviate blows against the ends of the cylinder, the latter (or the piston) may comprise a disc of resilient or semi-resilient material, such as very thick leather.

Figures 5 and 6 show a modification of construction according to which the springs 1, in order to diminish the space occupied when at rest or in stock, are wound in double coils, the extremities of each double coil being fixed to the end of the cylinder 7 and to the piston 2 respectively.

The device as a whole is shown, in Figures 5 and 6, fixed to a wing spar 20, by the aid of a bracket 21 and a tightening collar 22, the said unit being entirely arranged inside the wing, although in certain cases it might be mounted at least partially projecting to the outside of the wing, provided it is of suitable profile.

In order to obviate any mechanical friction between the mass 2 and the walls of the cylinder 7, while maintaining sufficient fluid-tightness to compress the damping fluid, circular grooves 10 (Figure 2) may for instance be provided upon the

piston, these grooves constituting expansion spaces, and thus considerably braking the fluid in its flow between piston and cylinder walls.

5 The guiding of the mass 2 will in any case be suitably effected in order to obviate jamming, the said mass or piston comprising for this purpose a skirt for example of adequate height.

10 Of course means may advantageously be provided for regulating the characteristics of the reciprocable inertia-mass system, particularly for regulating the elastic force or the damping force; in this latter case, the said means are provided for example, if it is a question of damping by friction, by tightening the jaws 3, Figs. 3, 4, to a greater or less extent by the aid of a screw 11 and against the action of at least one spring 12; and, if it is a question of fluid damping, by varying the cross-section of the throttling passage, by the aid of valves 9 for instance.

20 Finally, concerning the position to be adopted for the reciprocable inertia mass in question, the latter will preferably be arranged, as already stated, close to a vibration node. In applying it to an aeroplane wing, it will consequently be advantageous to arrange it at the free end of the said wing (Figure 1), if this latter can comprise a beam fixed or built in at one of its extremities at E, where the curve of oscillation C presents a node, while it presents a crest or antinode at its opposite end.

In this way the most dangerous vibration, that is to say the fundamental vibration, can be suppressed.

40 Nevertheless, it will not often be possible to arrange the vibration-damping system at the end of the wing and in the interior of the latter, on account of the tapered form of the wings and the thinness thereof at the extremities.

45 It will then be advantageous to arrange the said system in a plane A (Figure 9) in the neighbourhood of the node N₂ of the third harmonic C₂.

50 Under these conditions, on the one hand the second harmonic C₂ is almost completely suppressed, since at A the amplitude of this harmonic is already two-thirds of the maximum amplitude, and on the other hand the third harmonic is encouraged, which can only have advantages, since the amplitude of this harmonic at the end of the wing is negative, and consequently gives an energy of a sign contrary to that of the fundamental, which has the immediate effect of straightening the wing at its position of rest.

65 As a result, what ever may be the form of construction adopted, such a composite

unit is obtained that it is possible to deaden in considerable proportions the oscillations of any part whatever, owing to the presence of a reciprocable inertia mass system in accordance with the foregoing provisions.

Experiment and calculation show that a reciprocable inertia mass system of this type takes up very little space, and the stroke of the mass 2 can be made sufficiently small to enable the unit to be lodged in the interior of a wing.

70 It is thus possible in this application to aeroplanes in particular, by the addition of very light devices, to suppress entirely the risk of fracture of the wings owing to resonance vibrations. Even if the devices in question are not regulated to the resonance frequency, very good results are still obtained. Thus the device of Figures 3 and 4, or that of Figures 5 and 6, in the case in which its intrinsic frequency differed by 25 per cent. from the resonance frequency of its support, when placed in a wing for example, would enable a damping to be obtained of 81 per cent. in amplitude, or 90.7 per cent. in energy.

Of course the direction of the displacements of the reciprocable mass will be selected in each particular case as a function of the direction of the vibrations to be damped. Thus in a wing, a plurality of devices might be provided, acting so as to damp the various components of the vibrations.

It is also possible to damp torsional vibrations in a similar manner. If for example one considers a point of the structure not situated on the neutral line about which torsion is effected and if at this point a device is arranged of the kind shown in Figures 1 and 2 wherein the axis of the cylinder is arranged tangentially to the curve described by the said point upon torsional movement, such an arrangement would constitute a device for damping torsional vibrations.

It is also possible to apply the invention to ailerons such as 23 (Figures 7 and 8), in which case the damping device is arranged on the other side of the aileron relative to its oscillation axis in such a way as to act as a counterpoise.

120 The device will in this case be carried for example by an arm or arms 25, and an aperture 26 may be made in the wing for it to pass through. A weight 24 may be provided in the case where the weight of the device is not sufficient to balance the weight of the aileron.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim 130

is:—

1. An aircraft fixed wing or supporting surface of the kind specified characterised by the feature that it comprises at least one vibration damping system arranged in such a way as to destroy the kinetic energy tending to maintain the said vibrations, the assembly being such as to avoid the accumulation of the vibratory energy.
2. A vibration damping system for an aircraft fixed wing or supporting surface as claimed in claim 1, characterised by the feature that it comprises at least one mass oscillating in opposition to the action of resilient means and giving rise to frictional work during its displacements.
3. A vibration damping system for an aircraft fixed wing or supporting surface as claimed in claims 1 and 2, characterised by the feature that its oscillatory period is substantially the same as the period proper of the wing.
4. A vibration damping system for an aircraft fixed wing or supporting surface as claimed in any one of the preceding claims, characterised by the feature that the anti-vibratory device is arranged close to the free end of the wing.
5. A vibration damping system for an aircraft fixed wing or supporting surface as claimed in Claims 1 to 3, characterised by the feature that the said system is arranged in a plane adjacent to the node (N₂) of the third harmonic of the vibrating member.
6. A vibration damping system for an aircraft fixed wing or supporting surface as claimed in Claims 1 to 3, characterised by the feature that a plurality of oscillating anti-vibratory devices are arranged at different points of the vibrating surface to be damped.
7. A vibration damping system for an aircraft fixed wing or supporting surface as claimed in Claims 1 to 3, characterised by the feature that the oscillating anti-vibratory device or devices are carried by a spar.
8. A vibration damping system for an aircraft fixed wing or supporting surface as claimed in Claims 1 to 3, characterised by the feature that it comprises a mass, subject to the action of springs and forming a piston in the interior of a cylinder carried by the part of which the vibrations are to be damped.
9. A vibration damping system for an aircraft fixed wing or supporting surface as claimed in Claim 8, characterised by the feature that the said piston, in moving, forces a liquid or gaseous fluid through a throttling member, which is preferably adjustable in cross sectional area.
10. A vibration damping system for an aircraft fixed wing or supporting surface as claimed in Claim 8 or 9, characterised by the feature that means are arranged in the ends of the cylinder for absorbing any shocks that might occur.
11. A vibration damping system for an aircraft fixed wing or supporting surface as claimed in Claim 8, characterised by the feature that the springs are of the double spiral type.
12. A vibration damping system for an aircraft fixed wing or supporting surface as claimed in Claim 8, characterised by the feature that the piston is provided at its periphery with circular grooves forming expansion spaces.
13. A vibration damping system for an aircraft fixed wing or supporting surface of the kind specified substantially as hereinbefore described and illustrated in the accompanying drawings.

Dated this 30th day of December, 1935.

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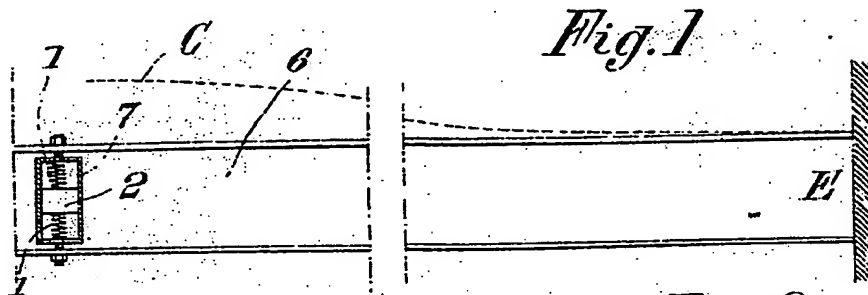


Fig. 1

Fig. 2.

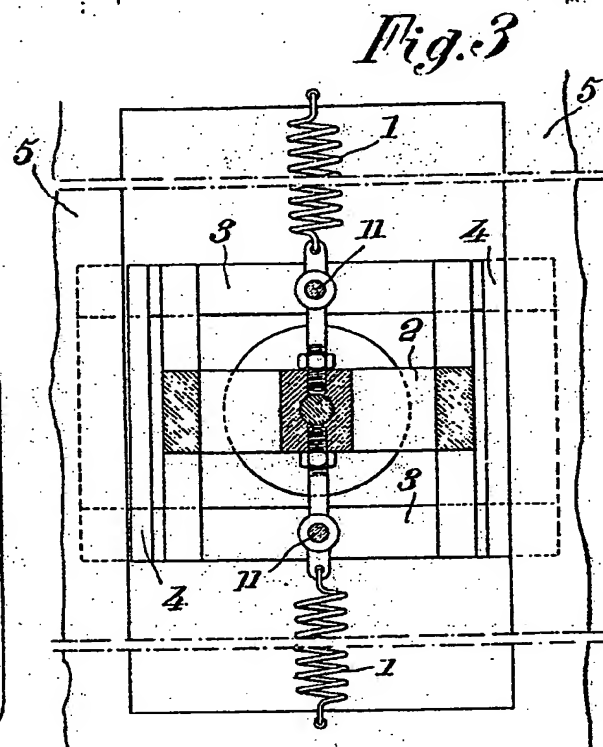
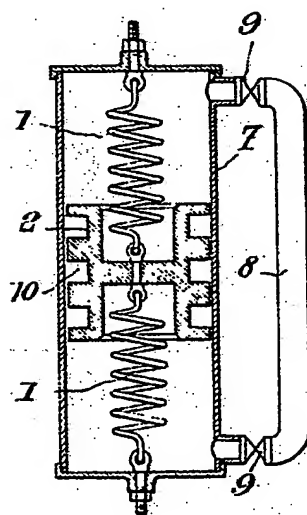


Fig. 3

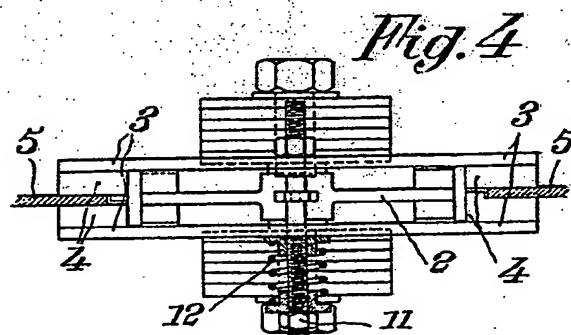


Fig. 4

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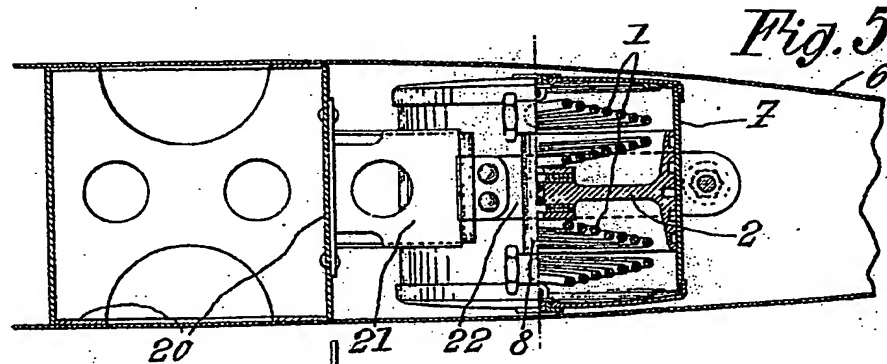
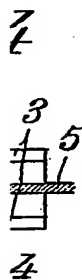
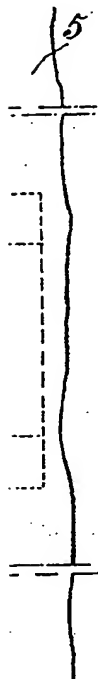


Fig. 6

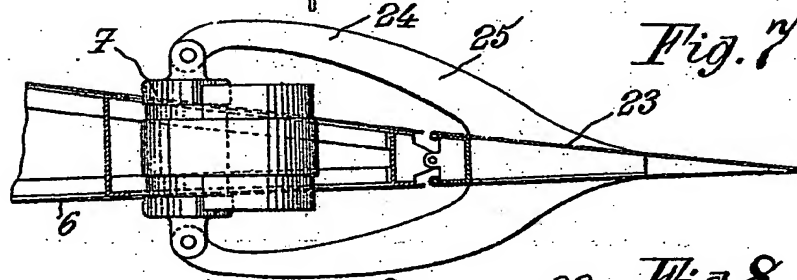
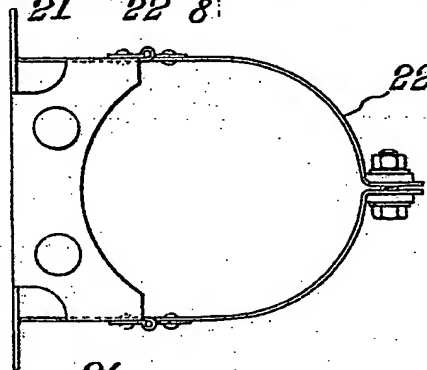


Fig. 7

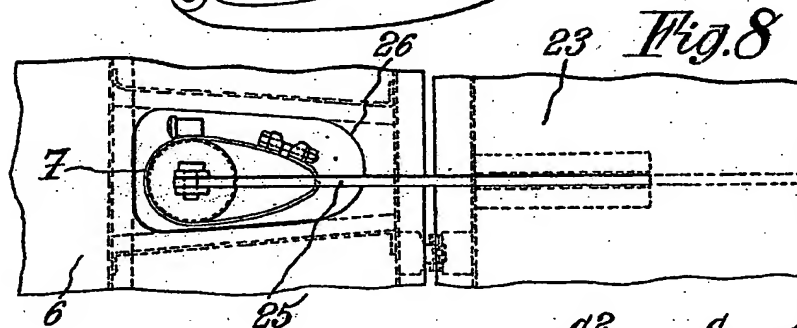
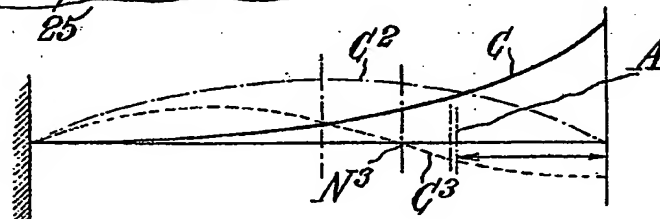


Fig. 8

Fig. 9



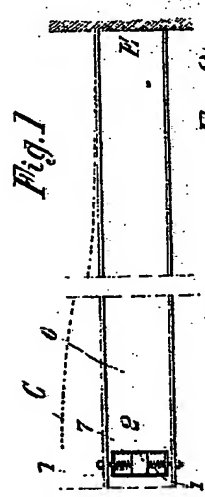


Fig. 1

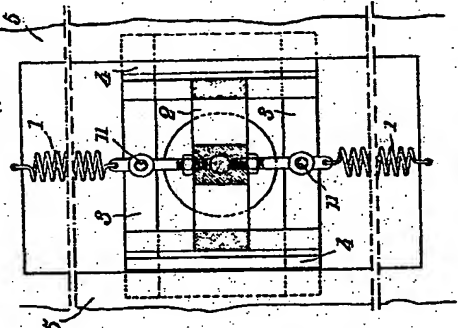


Fig. 3

Fig. 2.

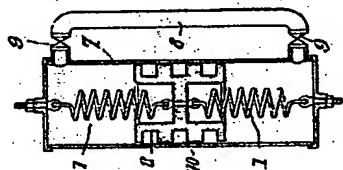


Fig. 4

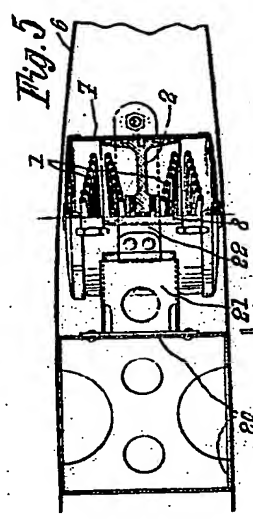
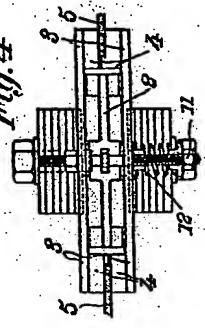


Fig. 5

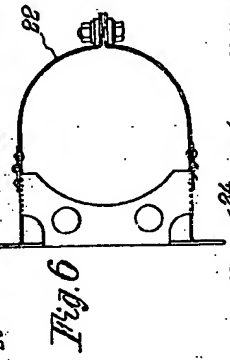


Fig. 6

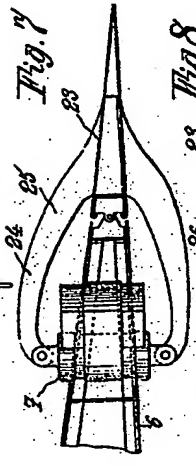


Fig. 7

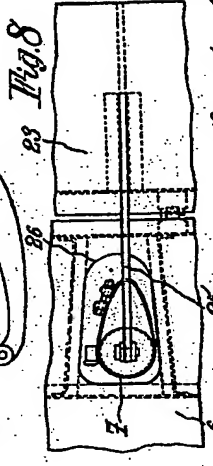


Fig. 8



Fig. 9

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